BS EN 60384-9:2015

BSI Standards Publication

Fixed capacitors for use in electronic equipment

Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2

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National foreword

This British Standard is the UK implementation of EN 60384-9:2015. It is identical to IEC 60384-9:2015. It supersedes BS EN 60384-9:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/40X, Capacitors and resistors for electronic equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Fixed capacitors for use in electronic equipment - Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2 (IEC 60384-9:2015)

Condensateurs fixes utilisés dans les équipements électroniques - Partie 9: Spécification intermédiaire: Condensateurs fixes à diélectrique en céramique, Classe 2 (IEC 60384-9:2015)

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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 40/2339/FDIS, future edition 4 of IEC 60384-9, prepared by IEC TC 40, "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60384-9:2015.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-01-14
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2018-04-14

This document supersedes EN 60384-9:2005.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60384-9:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60384-14	NOTE	Harmonized as EN 60384-14.
IEC 60384-22	NOTE	Harmonized as EN 60384-22.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60063	1963	Preferred number series for resistors and capacitors	-	-
+A1	1967		-	-
+A2	1977		-	-
IEC 60068-1	2013	Environmental testing -- Part 1: General and guidance	EN 60068-1	2014
IEC 60384-1	2008	Fixed capacitors for use in electronic equipment -- Part 1: Generic specification	EN 60384-1	2009
IEC 61193-2	2007	Quality assessment systems -- Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	2007
ISO 3	1973	Preferred numbers; Series of preferred numbers	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2

FOREWORD

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International Standard IEC 60384-9 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This fourth edition cancels and replaces the third edition published in 2005. This fourth edition is a result of maintenance activities related to the previous edition. All changes that have been agreed upon can be categorized as minor revisions.

The text of this standard is based on the following documents:

FDIS	Report on voting
40/2339/FDIS	40/2364/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60384 series, published under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2

1 General

1.1 Scope

This part of IEC 60384 is applicable to fixed capacitors of ceramic dielectric with a defined temperature coefficient (dielectric Class 2), intended for use in electronic equipment, including leadless capacitors but excluding fixed surface mount multilayer capacitors of ceramic dielectric, which are covered by IEC 60384-22 (Class 2).

Capacitors for electromagnetic interference suppression are not included, but are covered by IEC 60384-14.

1.2 Object

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:2008 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification shall be of equal or higher performance level because lower performance levels are not permitted.

1.3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60063:1963, *Preferred number series for resistors and capacitors*
IEC 60063:1963/AMD1:1967
IEC 60063:1963/AMD2:1977

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:2008, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

ISO 3:1973, *Preferred numbers – Series of preferred numbers*

1.4 Information to be given in a detail specification

1.4.1 General

Detail specifications shall be derived from the relevant blank detail specification.

Detail specifications shall not specify requirements inferior to those of the generic, sectional or blank detail specification. When more severe requirements are included, they shall be

listed in 1.9 of the detail specification and indicated in the test schedules, for example by an asterisk.

The information given in 1.4.2 may for convenience, be presented in tabular form.

The following information shall be given in each detail specification and the values quoted shall preferably be selected from those given in the appropriate clause of this sectional specification.

1.4.2 Outline drawing and dimensions

There shall be an illustration of the capacitor as an aid to easy recognition and for comparison of the capacitor with others.

Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions shall preferably be stated in millimetres, however when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

Normally, the numerical values shall be given for the length of the body, the width and height of the body and the wire spacing, or for cylindrical types, the body diameter, and the length and diameter of the terminations. When necessary, for example when a number of items (capacitance values/voltage ranges) are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitors. When the capacitor is not designed for use on printed boards, this shall be clearly stated in the detail specification.

1.4.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and the bump or shock tests.

1.4.4 Ratings and characteristics

1.4.4.1 General

The ratings and characteristics shall be in accordance with the relevant clauses of this standard, together with the following:

1.4.4.2 Nominal capacitance range

See 2.2.4.1.

When products approved to the detail specification have different ranges, the following statement should be added: “The range of capacitance values available in each voltage range is given in the register of approvals”.

1.4.4.3 Particular characteristics

Additional characteristics may be listed, when they are considered necessary to specify adequately the component for design and application purposes.

1.4.4.4 Soldering

The detail specification shall prescribe the test methods, severities and requirements applicable for the solderability and the resistance to soldering heat tests.

1.4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. Deviations from 1.6 shall be specifically stated.

1.5 Terms and definitions

For the purposes of this document, the applicable terms and definitions of IEC 60384-1 as well as the following apply.

1.5.1
fixed capacitors, ceramic dielectric, Class 2
capacitor which has a dielectric with a high permittivity and is suitable for by-pass and coupling applications or for frequency discriminating circuits where low losses and high stability of capacitance are not of major importance

Note 1 to entry: The ceramic dielectric is characterized by the non-linear change of capacitance over the category temperature range (see Table 2).

1.5.2
subclass
maximum percentage change of capacitance within the category temperature range with respect to the capacitance at 20 °C

Note 1 to entry: The subclass may be expressed in code form (see Table 2).

1.5.3
rated voltage
U_R
maximum d.c. voltage which may be applied continuously to the terminations of a capacitor at the rated temperature

Note 1 to entry: Maximum d.c. voltage is the sum of the d.c. voltage and peak a.c. voltage or peak pulse voltage applied to the capacitor.

[SOURCE: IEC 60384-1:2008, 2.2.25, modified (addition of "the terminations of")]

1.6 Marking

1.6.1 General

See IEC 60384-1:2008, 2.4, with the following details:

The information given in the marking is normally selected from the following list; the relative importance of each item is indicated by its position in the list:

a) nominal capacitance;
b) rated voltage (d.c. voltage may be indicated by the symbol ⎓ or ⎓);
c) tolerance on nominal capacitance;
d) the dielectric subclass, see Table 2;
e) year and month (or week) of manufacture;
f) manufacturer's name or trade mark;
g) climatic category;

h) manufacturer's type designation;

i) reference to the detail specification.

Information required under b) and d) may be given in code form under manufacturer's, or national, type or style designation.

1.6.2 Marking on the body

The capacitor shall be clearly marked with a), b) and c) of 1.6.1 and with as many as possible of the remaining items as is considered necessary. Any duplication of information in the marking on the capacitor should be avoided.

1.6.3 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 1.6.1.

1.6.4 Additional marking

Any additional marking shall be so applied that no confusion can arise.

2 Preferred ratings and characteristics

2.1 Preferred characteristics

Preferred climatic categories only shall be given in the preferred characteristics.

The capacitors covered by this standard are classified into climatic categories according to the general rules given in IEC 60068-1:2013, Annex A.

The lower and upper category temperatures and the duration of the damp heat, steady state test shall be chosen from the following:

- lower category temperature: –55 °C, –40 °C, –25 °C and –10 °C
- upper category temperature: +70 °C, +85 °C, +100 °C and +125 °C
- duration of the damp heat, steady state test (40 °C, 93 % RH): 4, 10, 21 and 56 days

The severities for the cold and dry heat tests are the lower and upper category temperatures respectively.

2.2 Preferred values of ratings

2.2.1 Rated temperature

For capacitors covered by this standard, the rated temperature is equal to the upper category temperature.

2.2.2 Rated voltage (U_R)

The preferred values of rated voltage are: 25, 40, 63, 100, 160, 250, 400, 630, 1 000, 1 600, 2 500, 4 000 and 6 300 V. These values conform to the basic series of preferred values R5 given in ISO 3. If other values are needed they shall be chosen from the R10 series.

The sum of the d.c. voltage and the peak a.c. voltage applied to the capacitor should not exceed the rated voltage. The value of the peak alternating voltage should not exceed the value determined by the permissible reactive power.

2.2.3 Category voltage (U_C)

Since the rated temperature is defined as the upper category temperature, the category voltage is equal to the rated voltage, as defined in IEC 60384-1:2008, 2.2.5.

2.2.4 Preferred values of nominal capacitance and associated tolerance values

2.2.4.1 Preferred values of nominal capacitance

Nominal capacitance values shall be taken from the E3, E6 and E12 series given in IEC 60063 preferably.

2.2.4.2 Preferred tolerances on nominal capacitance

Table 1 denotes the preferred values of tolerance on nominal capacitance.

Table 1 – Preferred tolerance on nominal capacitance

Preferred series	Tolerances %	Letter code
E3 and E6	–20/+80	Z
	–20/+50	S
E6	±20	M
E6 and E12	±10	K

2.2.5 Temperature characteristic of capacitance

Table 2 denotes with a cross the preferred values of temperature characteristics with and without d.c. voltage applied. The method of coding the subclass is also given; for example a dielectric with a percentage change of ±20 % without d.c. voltage applied over the temperature range from -55 °C to +125 °C, will be defined as a dielectric of Class 2C1.

Table 2 – Preferred values of temperature characteristics

Sub-class letter code	Maximum capacitance change in per cent within the category temperature range with respect to the capacitance at 20 °C measured with and without a d.c. voltage applied		Category temperature range and corresponding number code				
			-55/+125 °C	-55/+85 °C	-40/+85 °C	-25/+85 °C	-10/+85 °C
	Without d.c. voltage applied	With d.c. voltage applied [a]	1	2	3	4	6
2B	±10	As specified in the detail specification	-	x	x	x	-
2C	±20		x	x	x	-	-
2D	+20/–30		-	-	-	x	-
2E	+22/–56		-	x	x	x	x
2F	+30/–80		-	x	x	x	x
2R	±15		x	-	-	-	-
2X	±15	+15/–25	x	-	-	-	-

NOTE x indicates: applied;

– indicates: not applied.

[a] The applied voltage is the rated d.c. voltage or as specified in the detail specification.

The temperature range, for which the temperature characteristics of the dielectric is defined, is the same as the category temperature range.

3 Quality assessment procedures

3.1 Primary stage of manufacture

For single layer capacitors, the primary stage of manufacture is the metallizing of the dielectric to form the electrode; for multilayer capacitors it is the first common firing of the dielectric-electrode assembly.

3.2 Structurally similar components

Capacitors, considered as being structurally similar, are capacitors produced with similar processes and materials, though they may be of different case sizes and values.

3.3 Certified test records of released lots

The information required in IEC 60384-1:2008, Q.9, shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the parameters for which variables information is required are the capacitance change, tan δ and the insulation resistance.

3.4 Qualification approval

3.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2008, Q.5.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 3.5. The procedure using a fixed sample size schedule is given in 3.4.2 and 3.4.3.

3.4.2 Qualification approval on the basis of the fixed sample size procedure

The fixed sample size procedure is described in IEC 60384-1:2008, Q.5.3 b). The sample shall be representative of the range of capacitors for which approval is sought. This may or may not be the complete range covered by the detail specification.

The samples shall consist of specimens having the lowest and highest voltages, and for these voltages the lowest and highest capacitance values. When there are more than four rated voltages an intermediate voltage shall also be tested. Thus, for the approval of a range, testing is required of either four or six values (capacitance/voltage combinations). When the range consists of less than four values, the number of specimens to be tested shall be that required for four values.

Spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value may be used as replacements for specimens which are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so, the numbers may be reduced accordingly.

When additional groups are introduced into the qualification approval test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table 3 gives the number of samples to be tested in each group or subgroup together with the number of permissible non-conformances for qualification approval tests.

3.4.3 Tests

The complete series of tests specified in Table 3 and Table 4 are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

The whole sample shall be subjected to the tests of Group 0 and then divided for the other groups.

Non-conforming specimens found during the tests of Group 0 shall not be used for the other groups.

“One non-conforming item” is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

The approval is granted when the number of non-conforming items is zero.

Tables 3 and 4 together form the fixed sample size test schedule for which Table 3 includes the details for the sampling and permissible non-conforming item for the different tests or groups of test, whereas Table 4 together with the details of test contained in Clause 4 gives a complete summary of test conditions and performance requirements and indicates where, for example for the test method or conditions of test, a choice has to be made in the detail specification.

The conditions of test and performance requirements for the fixed sample size test schedule shall be identical to those prescribed in the detail specification for quality conformance inspection.

Table 3 – Sampling plan together with numbers of permissible non-conforming items for qualification approval tests, assessment level EZ

Group N°.	Test	Subclause of this publication	Number of specimens n [b]	Permissible number of non-conforming items c [d]
0	Visual examination	4.3		
	Dimensions	4.3		
	Capacitance	4.4.1		
	Tangent of loss angle	4.4.2	108	0
	Insulation resistance	4.4.3		
	Voltage proof	4.4.4		
	Spare specimens		8	
1A	Robustness of terminations	4.6	12	0
	Resistance to soldering heat	4.7		
	Component solvent resistance [c]	4.16		
1B	Solderability	4.8	24	0
	Solvent resistance of the marking [c]	4.17		
	Rapid change of temperature [a]	4.9		
	Vibration	4.10		
	Bump or shock [a]	4.11 or 4.12		
1	Climatic sequence	4.13	36	0
2	Damp heat, steady state	4.14	24	0
3	Endurance	4.15	36	0
4	Temperature characteristic of capacitance	4.5	12	0

a As required in the detail specification.

b Capacitance/voltage combinations, see 3.4.1.

c If required in the detail specification.

d This is the acceptance number, and not exceeded for acceptance.

Table 4 – Test schedule for qualification approval *(1 of 4)*

Subclause number and test [a]	D or ND [b]	Conditions of test [a]	Number of specimens (n) and number of permissible non-conforming items (c) [c]	Performance requirements [a]
Group 0	ND		See Table 3	
4.3 Visual examination				As in 4.3 Legible marking and as specified in the detail specification
4.3 Dimensions (detail)				See detail specification
4.4.1 Capacitance		Frequency: … kHz or MHz Measuring voltage: … V		Within specified tolerance
4.4.2 Tangent of loss angle (tan δ)		Frequency and measuring voltage (see 4.4.1)		As in 4.4.2.3
4.4.3 Insulation resistance		See detail specification for the method		As in 4.4.3.3
4.4.4 Voltage proof		See detail specification for the method		No breakdown or flashover
Group 1A	D		See Table 3	
4.6 Robustness of terminations		Visual examination		No visible damage
4.7.3 Initial measurements		Capacitance		
4.7 Resistance to soldering heat		Special preconditioning as in 4.2		
		See detail specification for the method		
4.7.5 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.7.5
4.16 Component solvent resistance (if applicable)		Solvent: … Solvent temp: … Method 2 Recovery: …		See detail specification

Table 4 *(2 of 4)*

Subclause number and test [a]	D or ND [b]	Conditions of test [a]	Number of specimens (n) and number of permissible non-conforming items (c) [c]	Performance requirements [a]
Group 1B	D		See Table 3	
4.8 Solderability		See detail specification for the method		Good tinning as evidenced by free flowing of the solder with wetting of the terminations, or see the detail specification for wetting balance method
4.17 Solvent resistance of the marking (if applicable)		Solvent: ... Solvent temperature:... Method 1 Rubbing material: cotton wool Recovery: ...		Legible marking
4.9 Rapid change of temperature		Special preconditioning as in 4.2		
4.9.3 Initial measurement		Capacitance T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t_1 = 30 min Recovery: 24 h ± 2 h		
		Visual examination		No visible damage
4.10 Vibration		For mounting method see detail specification Frequency range: from ... Hz to ... Hz Amplitude: 0,75 mm or acceleration 100 m/s^2 (whichever is the less severe) Total duration: 6 h		
4.10.3 Intermediate inspection		Visual examination		No visible damage
4.11 Bump (or shock, see 4.12)		For mounting method see detail specification Number of bumps: ... Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.12 Shock (or bump, see 4.11)		For mounting method see detail specification Acceleration: ... m/s^2 Duration of pulse: ... ms		
4.11.4 Final measurements or 4.12.4		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.12.4

Table 4 *(3 of 4)*

Subclause number and test [a]	D or ND [b]	Conditions of test [a]	Number of specimens (n) and number of permissible non-conforming items (c) [c]	Performance requirements [a]
Group 1	D		See Table 3	
4.13 Climatic sequence		Special preconditioning as in 4.2		
4.13.3 Initial measurement		Capacitance		
4.13.4 Dry heat		Temperature: upper category temperature Duration: 16 h		
4.13.5 Damp heat, cyclic, Test Db, first cycle				
4.13.6 Cold		Temperature: lower category temperature Duration: 2 h		
		Visual examination		No visible damage
4.13.7 Low air pressure (if required by the detail specification		Air pressure: 8 kPa		
4.13.7.4 Intermediate inspection		Visual examination		No breakdown or flashover
4.13.8 Damp heat, cyclic, Test Db, remaining cycles		Recovery: 24 h ± 2 h		
4.13.8.4 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.13.8.4
		Tangent of loss angle		As in 4.13.8.4
		Insulation resistance		As in 4.13.8.4
Group 2	D		See Table 3	
4.14 Damp heat, steady state		Special preconditioning as in 4.2		
4.14.3 Initial measurements		Capacitance		
		Recovery: 24 h ± 2 h		
4.14.6 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.14.6
		Tangent of loss angle		As in 4.14.6
		Insulation resistance		As in 4.14.6

Table 4 *(4 of 4)*

Subclause number and test [a]	D or ND [b]	Conditions of test [a]	Number of specimens (n) and number of permissible non-conforming items (c) [c]	Performance requirements [a]
Group 3	D		See Table 3	
4.15 Endurance		Special preconditioning as in 4.2		
		Voltage: V		
		Duration: h		
4.15.3 Initial measurement		Capacitance		
		Recovery: 24 h ± 2 h		
4.15.6 Final measurements		Visual examination		No visible damage Legible marking
		Capacitance		$\Delta C/C$ as in 4.15.6
		Tangent of loss angle		As in 4.15.6
		Insulation resistance		As in 4.15.6
Group 4	ND		See Table 3	
4.5 Temperature characteristic of capacitance		Special preconditioning as in 4.2		$\Delta C/C$ as in 4.5.3

[a] Subclause numbers of test and performance requirements refer to Clause 4.

[b] In this table: D = destructive, ND = non-destructive.

[c] This is the acceptance number, and not exceeded for acceptance.

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

3.5.1.1 Groups A and B inspection

These tests shall be carried out on a lot-by-lot basis.

A manufacturer may aggregate the current production into inspection lots subject to the following safeguards:

a) The inspection lot shall consist of structurally similar capacitors (see 3.2);

b) For Group A, the sample tested shall consist of each of the values and each of the dimensions contained in the inspection lot:

   – in relation to their number;

   – with a minimum of five of any one value.

   For subgroup B2 the sample shall include capacitors of every temperature characteristic represented in the lot.

c) If there are less than five of any one value in the sample the basis for the drawing of samples shall be agreed between the manufacturer and the Certification Body (CB).

3.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

Samples shall be representative of the current production of the specified periods and shall be divided into high, medium and low capacitance values. In subsequent periods, different voltage ratings and capacitance values in production shall be tested with the aim of covering the whole range.

3.5.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in Clause 2, Table 5 of the blank detail specification.

3.5.3 Delayed delivery

When according to the procedures of IEC 60384-1:2008, Q.10, re-inspection has to be made, solderability and capacitance shall be checked as specified in Groups A and B inspection.

3.5.4 Assessment levels

The assessment level(s) given in the blank detail specification shall preferably be selected from Tables 5 and 6.

Table 5 – Lot-by-lot inspection

Inspection subgroup [c]	EZ		
	IL	*n*	*c*
A0	100 % [a]		
A1	S-4	[b]	0
A2	S-3	[b]	0
B1	S-3	[b]	0
B2	S-2	[b]	0

IL = inspection level;
n = sample size;
c = permissible number of non-conforming items.

[a] The inspection shall be performed after removal of nonconforming items by 100 % testing during the manufacturing process. Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by nonconforming items per million ($\times 10^{-6}$).

The sampling level shall be established by the manufacturer, preferably according to IEC 61193-2:2007, Annex A.

In case one or more nonconforming items occur in a sample, this lot shall be rejected but all nonconforming items shall be counted for the calculation of quality level values. Outgoing quality level by nonconforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data according to the method given in IEC 61193-2:2007, 6.2.

[b] Number to be tested: Sample size shall be determined according to IEC 61193-2:2007, 4.3.2.

[c] The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

Table 6 – Periodic tests

Inspection subgroup [a]	EZ		
	p	*n*	*c*
C1A	6	9	0
C1B	6	18	0
C1	6	27	0
C2	6	15	0
C3	3	15	0
C4	12	9	0

p = periodicity in months;
n = sample size;
c = permissible number of non-conforming items.

[a] The content of the inspection subgroup is described in Clause 2 of the relevant blank detail specification.

4 Test and measurement procedures

4.1 General

This clause supplements the information given in IEC 60384-1:2008, Clause 4.

4.2 Special preconditioning

Unless otherwise specified in the detail specification, the special preconditioning, when specified in this document before a test or a sequence of tests, shall be made under the following conditions: exposure at upper category temperature or at such higher temperature as may be specified in the detail specification during 1 h, followed by recovery during 24 h ± 1 h at standard atmospheric conditions for testing.

NOTE Class 2 capacitors lose capacitance continuously with time according to a logarithmic law (this is called ageing). However if the capacitor is heated to a temperature above the Curie point of its dielectric then "de-ageing" takes place, i.e. the capacitance lost through "ageing" is regained, and "ageing" recommences from the time when the capacitor recools.

The purpose of special preconditioning is to bring the capacitor to a defined stage regardless of its previous history (see Clause A.4 for further information).

4.3 Visual examination and check of dimensions

See IEC 60384-1:2008, 4.4.

4.4 Electrical tests

4.4.1 Capacitance

4.4.1.1 General

See IEC 60384-1:2008, 4.7, with the following details:

4.4.1.2 Measuring conditions

The capacitance shall be measured according to Table 7 and the following details:

Table 7 – Measuring conditions

Subclass	Measuring voltage	Referee voltage [a]
2B, 2C, 2X	1,0 ± 0,2 V	1,0 ± 0,02 V
2D, 2E, 2F, 2R	0,3 ± 0,2 V or as specified in the detail specification	0,3 ± 0,02 V or as specified in the detail specification
[a] In case of dispute about results of measurements, referee voltage is applied.		

Frequency: C_N < 100 pF f = 1 MHz unless otherwise specified in the detail specification

$C_N \geq$ 100 pF f = 1 kHz ± 20 % for measuring purposes and
1 kHz for referee tests.

4.4.1.3 Requirements

The capacitance value shall correspond with the rated value taking into account the specified tolerance.

For referee measurements the capacitance value shall be the value extrapolated to an ageing time of 1 000 h, unless otherwise specified in the detail specification (for explanation see Annex A).

If applying the ageing time other than 1 000 h, that may be specified in the detail specification.

4.4.2 Tangent of loss angle (tan δ)

4.4.2.1 General

See IEC 60384-1:2008, 4.8, with the following details:

4.4.2.2 Measuring conditions

See 4.4.1.

4.4.2.3 Accuracy

The accuracy of the measuring instruments shall be such that the measuring error does not exceed 0,001.

4.4.2.4 Requirements

The tangent of loss angle shall not exceed 0,035; or such lower value as may be given in the detail specification.

4.4.3 Insulation resistance (R_i)

4.4.3.1 General

See IEC 60384-1:2008, 4.5, with the following details:

4.4.3.2 Measuring conditions

See IEC 60384-1:2008, 4.5.2, with the following details:

For U_R < 100 V, the measuring voltage may be of any value not greater than U_R, the reference voltage being U_R.

The voltage shall be applied immediately at the specified value for 1 min ± 5 s for qualification approval testing and periodic tests (Group C). For lot-by-lot testing (Group A), the test may be terminated in a shorter time, if the required value of insulation resistance is reached.

The product of the internal resistance of the voltage source and the nominal capacitance of the capacitor shall not exceed 1 s unless otherwise prescribed in the detail specification.

The charge current shall not exceed 0,05 A.

The insulation resistance (R_i) shall be measured at the end of the 1 min period.

4.4.3.3 Requirements

The insulation resistance (R_i) shall meet the requirements given in Table 8.

Table 8 – Insulation resistance requirements

Style	Measuring points	$C_N \leq 25$ nF	$C_N > 25$ nF
		R_i	$R_i \times C_N$
Insulated	1a and 1c	≥ 4 000 MΩ	≥ 100 s
Non-insulated	1a		

4.4.4 Voltage proof

4.4.4.1 General

See IEC 60384-1:2008, 4.6, with the following details:

4.4.4.2 Test conditions

The product of R_i and the nominal capacitance C_x shall be smaller than or equal to 1 s.

The charge current shall not exceed 0,05 A.

4.4.4.3 Test voltage

The voltages in Table 9 shall be applied between the measuring points of Table 3 in IEC 60384-1:2008 for a period of 1 min for qualification approval testing and for a period of 1 s for the lot-by-lot quality conformance testing.

Table 9 – Test voltages

Type	Rated voltage V	Test voltage V
Leaded multilayer ceramic capacitors	$U_R \leq 100$	2,5 U_R
	$100 < U_R \leq 200$	1,5 U_R + 100
	$200 < U_R \leq 500$	1,3 U_R + 100
	$500 < U_R$	1,3 U_R
Others	$U_R \leq 500$	2,5 U_R
	$U_R > 500$	1,5 U_R + 500
NOTE If $U_R > 500$ V, then the test voltage for Test C (external insulation) is 1,5 U_R + 500 V or as specified in the detail specification.		

4.4.4.4 Requirement

There shall be no breakdown or flashover during the test.

4.5 Temperature characteristic of capacitance

4.5.1 Special preconditioning

See 4.2.

4.5.2 Measuring conditions

See IEC 60384-1:2008, 4.24.1.2 and 4.24.1.3, with Table 10.

Table 10 – Details of measuring conditions

Measuring step	Temperature °C	DC voltage applied
1	20 ± 2	-
2	T_A [a] ± 3	-
3	20 ± 2	-
4	T_B [b] ± 2	-
5	T_B ± 2	x
6	20 ± 2	x
7	T_A ± 3	x
8	20 ± 2	-

NOTE 1 "-" indicates: no DC voltage applied.
"x" indicates: DC voltage applied (if specified in the detail specification)

NOTE 2 Intermediate measurement temperatures are used when ensuring the requirements of 2.2.5.

NOTE 3 Reference capacitance is the capacitance measured at Step 3.

NOTE 4 Because of the effects described in the Note in 4.2, the capacitance values measured at temperature reference, Steps 5 to 7, with DC voltage applied, are time dependent. This time dependency is included in the given limits for capacitance change. The capacitance change between the first and the last measurements at temperature reference, Steps 1 and 8, indicates the amount of ageing involved. In case of a dispute about the results of measurements with DC voltage applied, it is advisable to agree upon a fixed time interval between measurements at temperature reference, Steps 5 and 7 with DC voltage applied (see IEC 60384-1:2008, 4.24.1.3).

[a] T_A = Lower category temperature.

[b] T_B = Upper category temperature.

4.5.3 Requirements

The variation of capacitance shall be calculated according to IEC 60384-1:2008, 4.24.3.1.

The temperature characteristics with and without d.c. voltage applied shall not exceed the values given in Table 2.

4.6 Robustness of terminations

See IEC 60384-1:2008, 4.13.

4.7 Resistance to soldering heat

4.7.1 General

See IEC 60384-1:2008, 4.14, with the following details:

4.7.2 Special preconditioning

See 4.2.

4.7.3 Initial measurement

The capacitance shall be measured according to 4.4.1.

4.7.4 Recovery

The capacitors shall recover for 24 h ± 2h.

4.7.5 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The capacitances shall be measured according to 4.4.1, and the change shall not exceed the values in Table 11.

Table 11 – Maximum capacitance change

Subclass	Requirements
2B, 2C and 2X	±10 %
2D and 2R	±15 %
2E and 2F	±20 %
NOTE See 2.2.5 for explanation of the subclass codes.	

4.8 Solderability

4.8.1 General

See IEC 60384-1:2008, 4.15, with the following details:

4.8.2 Test conditions

The requirements for the globule test method shall be prescribed in the detail specification. When neither the solder bath nor the solder globule method is appropriate the soldering iron test shall be used with soldering iron size A.

4.8.3 Final inspection, measurements and requirements

The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations, or see the detail specification for the wetting balance method.

4.9 Rapid change of temperature (if required)

4.9.1 General

See IEC 60384-1:2008, 4.16, with the following details:

4.9.2 Special preconditioning

See 4.2.

4.9.3 Initial measurement

The capacitance shall be measured according to 4.4.1.

4.9.4 Test conditions

Number of cycles: 5.

Duration of exposure at the temperature limits: 30 min.

4.9.5 Recovery

The capacitors shall recover for 24 h ± 2h.

4.10 Vibration

4.10.1 General

See IEC 60384-1:2008, 4.17, with the following details:

4.10.2 Test conditions

The following degree of severity of test Fc applies:

0,75 mm displacement or 100 m/s^2, whichever is the lower amplitude, over one of the following frequency ranges: 10 Hz to 55 Hz, 10 Hz to 500 Hz, 10 Hz to 2 000 Hz. The total duration shall be 6 h.

The detail specification shall specify the frequency range and shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.10.3 Final inspection, measurements and requirements

The capacitors shall be visually examined. These shall be no visible damage.

4.11 Bump (repetitive shock)

4.11.1 General

See IEC 60384-1:2008, 4.18, with the following details:

The detail specification shall state whether the bump (repetitive shock) or the non-repetitive shock test applies.

4.11.2 Initial measurements

Not required.

4.11.3 Test conditions

The detail specification shall state which of the following preferred severities applies:

Total number of bumps:	1 000	or	4 000
Acceleration:	400 m/s^2	or	100 m/s^2
Pulse duration:	6 ms		16 ms

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.11.4 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements given in 4.12.4.

4.12 Shock (non-repetitive shock)

4.12.1 General

See IEC 60384-1:2008, 4.19, with the following details:

The detail specification shall state whether the bump (repetitive shock) or the non-repetitive shock test applies.

4.12.2 Initial measurements

Not required.

4.12.3 Test conditions

The detail specification shall state which of the preferred severities applies as stated in Table 12.

Pulse-shape: half-sine

Table 12 – Preferred severities (of non-repetitive shock)

Peak acceleration m/s^2	Corresponding duration of the pulse ms
300	18
500	11
1 000	6

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.12.4 Final inspection, measurements and requirements

The capacitors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The capacitance shall be measured according to 4.4.1, the change shall not exceed the values in Table 13.

Table 13 – Maximum capacitance change

Subclass	Requirements
2B, 2C and 2X	±10 %
2D and 2R	±15 %
2E and 2F	±20 %
NOTE See 2.2.5 for explanation of the subclass codes.	

4.13 Climatic sequence

4.13.1 General

See IEC 60384-1:2008, 4.21, with the following details:

4.13.2 Special preconditioning

See 4.2.

4.13.3 Initial measurements

The capacitance shall be measured in accordance with 4.4.1.

4.13.4 Dry heat

See IEC 60384-1:2008, 4.21.2.

4.13.5 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2008, 4.21.3.

4.13.6 Cold

See IEC 60384-1:2008, 4.21.4, with the following details:

The capacitor shall be visually examined. These shall be no visible damage.

4.13.7 Low air pressure

4.13.7.1 General

See IEC 60384-1:2008, 4.21.5, with the following details:

4.13.7.2 Test conditions

The test, if required in the detail specification, shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa.

The duration of the test shall be 1 h.

4.13.7.3 Test procedures

Immediately after achieving the low pressure, U_R shall be applied for 1 min to 2 min.

4.13.7.4 Final inspection and requirements

The capacitors shall be visually examined. These shall be no visible damage.

4.13.8 Damp heat, cyclic, Test Db, remaining cycles

4.13.8.1 General

See IEC 60384-1:2008, 4.21.6, with the following details:

4.13.8.2 Test conditions

The test conditions are shown in Table 14.

No voltage applied.

Table 14 – Number of damp heat cycles

Category	Number of cycles of 24 h
-/-/56	5
-/-/21	1
-/-/10	1
-/-/04	0

4.13.8.3 Recovery

The capacitors shall recover for 24 h ± 2 h.

4.13.8.4 Final inspection, measurements and requirements

The capacitors shall be visually examined.

There shall be no visible damage and the marking shall be legible.

The capacitors shall be measured and shall meet the following requirements given in Table 15. If the capacitance value is less than the minimum value permitted, then after the other measurements have been made the capacitor shall be preconditioned according to 4.2 and then the requirement in Table 15 shall be met.

Table 15 – Final inspection measurements and requirements

Measurement	Measuring conditions	Requirements			
		Subclasses 2B, 2C and 2X	Subclass 2D and 2R	Subclass 2E	Subclass 2F
Capacitance	4.4.1	$\Delta C/C \leq \pm$ 10 %	$\Delta C/C \leq \pm$ 15 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 30 %
Tangent of loss angle	4.4.2	tan $\delta \leq 2 \times$ value of 4.4.2.3			
Insulation resistance	4.4.3	$R_i \geq$ 1 000 MΩ or $R_i \times C_N \geq$ 25 s (whichever is the less)			
NOTE See 2.2.5 for explanation of the subclass codes.					

4.14 Damp heat, steady state

4.14.1 General

See IEC 60384-1:2008, 4.22, with the following details:

4.14.2 Special preconditioning

See 4.2.

4.14.3 Initial measurement

The capacitance shall be measured according to 4.4.1.

4.14.4 Test conditions

No voltage applied, unless otherwise specified in the detail specification.

The severity of test should be selected from the test conditions as shown in Table 16 and specified in the detail specification.

The duration time should be selected in accordance with 2.1 and shall be specified in the detail specification.

Table 16 – Test conditions for damp heat, steady state

Severity	Temperature °C	Relative humidity %
1	+85 ± 2	85 ± 3
2	+60 ± 2	93 ± 3
3	+40 ± 2	93 ± 3

When the application of voltage is prescribed, U_R shall be applied to one half of the lot and no voltage shall be applied to the other half of the lot.

4.14.5 Recovery

The capacitors shall recover for 24 h ± 2 h.

4.14.6 Final inspection, measurements and requirements

The capacitors shall be visually examined.

There shall be no visible damage and the marking shall be legible.

The capacitors shall be measured and shall meet the following requirements given in Table 16. If the capacitance value is less than the minimum value permitted, then after the other measurements have been made the capacitor shall be preconditioned according to 4.2 and then the requirement in Table 17 shall be met.

Table 17 – Final inspection, measurements and requirements

Measurement	Measuring conditions	Requirements			
		Subclasses 2B, 2C and 2X	Subclass 2D and 2R	Subclass 2E	Subclass 2F
Capacitance	4.4.1	$\Delta C/C \leq \pm$ 10 %	$\Delta C/C \leq \pm$ 15 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 30 %
Tangent of loss angle	4.4.2	tan $\delta \leq 2 \times$ value of 4.4.2.3			
Insulation resistance	4.4.3	$R_i \geq$ 1 000 MΩ or $R_i \times C_N \geq$ 25 s (whichever is less)			
NOTE See 2.2.5 for explanation of the subclass codes.					

4.15 Endurance

4.15.1 General

See IEC 60384-1:2008, 4.23, with the following details:

4.15.2 Special preconditioning

See 4.2.

4.15.3 Initial measurement

The capacitance shall be measured according to 4.4.1.

4.15.4 Test conditions

The capacitors shall be tested according to Table 18.

Table 18 – Endurance test conditions

Type	Temperature	Rated voltage V	Test voltage V	Duration h
Leaded multilayer ceramic capacitors	Upper category temperature	$U_R \leq 200$	1,5 U_R	1 000
		$200 < U_R \leq 500$	1,3 U_R	1 500
		$500 < U_R$	1,2 U_R	2 000
Others	Upper category temperature	U_R	1,5 U_R	1 000

4.15.5 Recovery

The capacitors shall recover for 24 h ± 2 h.

4.15.6 Final inspection, measurements and requirements

The capacitors shall be visually examined.

There shall be no visible damage and the marking shall be legible.

The capacitors shall be measured and shall meet the following requirements given in Table 18. If the capacitance value is less than the minimum value permitted, then after the other measurements have been made the capacitor shall be preconditioned according to 4.2 and then the requirement in Table 19 shall be met.

Table 19 – Final inspection, measurements and requirements

Measurement	Measuring conditions	Requirements			
		Subclasses 2B, 2C and 2X	Subclass 2D and 2R	Subclass 2E	Subclass 2F
Capacitance	4.4.1	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 20 %	$\Delta C/C \leq \pm$ 30 %
Tangent of loss angle	4.4.2	tan $\delta \leq 2 \times$ value of 4.4.2.3			
Insulation resistance	4.4.3	$R_i \geq$ 2 000 MΩ or $R_i \times C_N \geq$ 50 s (whichever is less)			
NOTE See 2.2.5 for explanation of the subclass codes.					

4.16 Component solvent resistance (if applicable)

See IEC 60384-1:2008, 4.31.

4.17 Solvent resistance of the marking (if applicable)

See IEC 60384-1:2008, 4.32.

Annex A
(informative)

Capacitance ageing of fixed capacitors of ceramic dielectric, Class 2

A.1 General

Most Class 2 dielectrics used for ceramic capacitors have ferroelectric properties, and exhibit a Curie temperature.

Above this temperature the dielectric has the highly symmetric cubic crystal structure whereas below the Curie temperature the crystal structure is less symmetrical. Although in single crystals this phase transition is very sharp, in practical ceramics, it is often spread over a finite temperature range, but in all cases it is linked with a peak in the capacitance/temperature curve.

Under the influence of thermal vibration, the ions in the crystal lattice continue to move to positions of lower potential energy for a long time after the dielectric has cooled through the Curie temperature. This gives rise to the phenomenon of capacitance ageing, whereby the capacitor continually decreases its capacitance.

However, if the capacitor is heated to a temperature above the Curie temperature, then de-ageing takes place; i.e. the capacitance lost through ageing is regained, and ageing recommences from the time when the capacitor recools.

A.2 Law of capacitance ageing

During the first hour after cooling through the Curie temperature, the loss of capacitance is not well defined, but after this time it follows a logarithmic law (see K.W. Plessner, Proc. Phys. Soc., vol. 69B, P1261, 1956) which can be expressed in terms of an ageing constant.

The ageing constant k is defined as the percentage loss of capacitance due to the ageing process of the dielectric which occurs during a "decade", i.e. a time in which the capacitor increases its age tenfold, for example from 1 h to 10 h.

As the law of decrease of capacitance is logarithmic, the percentage loss of capacitance will be $2 \times k$ between 1 h and 100 h and $3 \times k$ between 1 h and 1 000 h. This may be expressed mathematically by the following formula:

$$C_t = C_1\left(1 - \frac{k}{100} \times \lg t\right) \quad \text{(A.1)}$$

where

C_t is the capacitance t h after the start of the ageing process;

C_1 is the capacitance 1 h after the start of the aging process;

k is the ageing constant in percent per decade (as defined above);

t is the time in h from the start of the ageing process.

The ageing constant may be declared by the manufacturer for a particular ceramic dielectric, or it may be defined by de-ageing the capacitor and measuring the capacitance at two known times thereafter.

k is then given by the following formula:

$$k = \frac{100 \times (C_{t_1} - C_{t_2})}{C_{t_1} \times \lg t_2 - C_{t_2} \times \lg t_1} \quad \text{(A.2)}$$

If capacitance measurements are made three or more times, then it is possible to derive k from the slope of a graph where C_t is plotted against lg t.

During measurements of ageing, the capacitor should be maintained at a constant temperature so that capacitance variations due to the temperature characteristic do not mask those due to ageing.

A.3 Capacitance measurements and capacitance tolerance (see 4.4.1)

Because of ageing, it is necessary to specify a reference age at which the capacitance shall be within the prescribed tolerance. This is fixed at 1 000 h, since for practical purposes there is not much further loss of capacitance after this time.

In order to calculate the capacitance $C_{1\,000}$ after 1 000 h, the ageing constant shall be known or determined as in Clause A.2, when the following formula may be used:

$$C_{1\,000} = C_t \times \left[1 - \frac{k}{100}(3 - \lg t)\right] \quad \text{(A.3)}$$

For factory measurements, the loss of capacitance from the age at the time of measurement to 1 000 h age will be known and can be off-set by using asymmetric inspection tolerances.

For example, if it is known that the capacitance loss will be 5 %, then the capacitors may be inspected to limits of $^{+25}_{-15}$ % instead of ±20 %.

Capacitance is normally declared at 20 °C, and it may be necessary to measure at this temperature or correct the results to this temperature. Errors can also arise from heat from the hands, and capacitors should therefore always be handled with tweezers.

A.4 Special preconditioning (see 4.2)

In many of the tests in this standard, it is required to measure the capacitance change which results from a given conditioning (e.g. climatic sequence). In order to avoid the interfering effect of ageing, the capacitor is specially preconditioned before these tests by maintaining it for 1 h at the upper category temperature, followed by 24 h at standard atmospheric conditions for testing.

For those capacitors with a Curie temperature below the upper category temperature, this results in de-ageing and subsequently bringing the capacitors to an age of 24 h. The recovery after the conditioning is also arranged, if possible, to bring the capacitors to an age of 24 h, so that capacitance changes due to ageing are minimised.

If the Curie temperature of the dielectric is above the upper category temperature then the special preconditioning will not completely de-age the capacitor, but it will nevertheless bring it into a state where its capacitance is not so dependent on its previous history, and the same effect will be achieved, though not completely de-aged. In order to de-age such capacitors completely, temperatures up to 160 °C may be required, and this temperature could be deleterious to the encapsulation. Therefore, in the few cases where complete de-ageing of

such capacitors may be required, the detail specification shall be consulted for details and any necessary precautions.

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